We claim

1. An apparatus for non-contact detection of a substance in a target region, comprising:

a laser source for generation of a probing light emission;

an optical subsystem adapted to split a light emission into first and second emission components and to introduce a first delay to the second emission component relative to the corresponding first emission component;

a lens subsystem adapted to accept all of the components in sequence and direct them to a focal region proximate to the target region along an optical axis;

an excitation source adapted to direct energy at a wavelength corresponding to an absorption line in the spectrum of the substance, through the lens subsystem to the focal region, at a time between the first and second components so as to change the refractive index in the focal region if the substance is present in the target region before the passage of the second component through the focal region;

an emission coupler adapted to:

recover back-scattered returns of the emission components,

introduce a second delay to the first returned emission component relative to the second returned emission component in an amount equal to the first delay, and

coherently couple the emission components into a returned light emission; and

a detection subsystem adapted to measure components of the returned emission to determine if there has been a change in the phase of the second returned emission component as a result of the presence of the substance in the target region.

2. An apparatus as claimed in claim 1, wherein the first and second emission components have linear polarizations orthogonal to each other.

3. An apparatus as claimed in claim 2, wherein the first emission component is p-polarized.

4. An apparatus as claimed in claim 2, wherein the optical subsystem comprises a plurality of polarizers adapted to transmit the first emission component directly therebetween but to reflect the second emission component along a diverted optical path therebetween having an additional length that corresponds to the amount of the first delay.

5. An apparatus as claimed in claim 4, wherein the emission coupler is adapted to alter the polarization of the first and second recovered emission components so that they correspond to the polarization of the second and first emission components respectively and thereafter to return them through the optical subsystem to provide the second delay and to coherently couple the resulting emission components.

6. An apparatus as claimed in claim 5, wherein the emission coupler comprises a Faraday rotator adapted to rotate the linear polarization of the emission components by +45° before passing through the lens subsystem and to rotate the linear polarization of the recovered emission components by an additional +45°.

7. An apparatus as claimed in claim 2, wherein the detection subsystem comprises a detector of linearly polarized emission components of the returned emission.

8. An apparatus as claimed in claim 7, wherein the detector comprises a photodiode.

9. An apparatus as claimed in claim 1, wherein the lens subsystem comprises a dichroic mirror adapted to transmit the first and second emission components therethrough and to reflect the energy at a time between the first and second emission components along the optical axis.

10. An apparatus as claimed in claim 1, wherein the lens subsystem comprises a telescope lens assembly to increase the beam diameter.

11. An apparatus as claimed in claim 1, wherein the lens subsystem comprises an objective lens to focus the beam in the focal region.

12. An apparatus as claimed in claim 1, wherein the excitation source is a laser.

13. An apparatus as claimed in claim 12, wherein the excitation source is tunable to a wavelength corresponding to an absorption spectrum line of the substance.

14. An apparatus as claimed in claim 1, wherein the probing emission is emitted in the form of a probing pulse.

15. An apparatus as claimed in claim 14, wherein the laser source emits a reference pulse before the probing pulse.

16. An apparatus as claimed in claim 15, wherein the detection subsystem determines the presence of the substance in the target region by comparing the ratio of the amplitudes of orthogonally polarized components of a returned emission corresponding to the reference pulse with the ratio of the amplitudes of orthogonally polarized components of a returned emission corresponding to the probing pulse to detect a change in the phase of the second returned emission component correspondng to the probing pulse.

17. An apparatus as claimed in claim 1, wherein the laser emits the light emission as a continuous wave.

18. An apparatus as claimed in claim 17, wherein the detection subsystem is adapted to detect transients in the returned emission.

19. An apparatus as claimed in claim 18, wherein the detection subsystem detects the presence of the substance in the target region by detecting transients in the returned emission that are temporally related to the generation of energy by the excitation source.

20. A method for non-contact detection of a substance at a target region, comprising the steps of:

radiating a probing light emission;

splitting the emission into a first and second emission component;

delaying in time the second emission components relative to the first emission component;

directing all of the emission components in sequence to a focal region proximate to the target region;

directing energy at a wavelength corresponding to an absorption line in the spectrum of the substance to the focal region a a time between the first and second emission components so as to change the refractive index in the focal region if the substance is present in the target region;

recovering back-scattered returns of the emission components;

delaying in time first returned emission component relative to the second returned emission component by an amount equal to the initial delay;

coherent coupling the emission components into a returned emission;

measuring components of the returned emission to determine if there has been a change in the phase of the second returned emission component as a result of the presence of the substance in the target region.